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RUBBER INDUSTRY

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▶ ▶ The production of synthetic rubber in the United States is described, both before the war and after the war program was initiated. The principal types of rubber produced by the industry and methods employed for manufacture are outlined. By-product wastes from the production of synthetic rubber and from the manufacture of the principal materials employed in the processes are discussed, and tables are presented that show the effect of these wastes on operating plant effluents. The raw materials necessary for production of synthetic rubber (butadiene and styrene) are given. Methods adopted for recovery of partially or wholly processed materials from waste waters as well as treatment facilities now installed are described. The design of treatment facilities is touched upon and chemical methods for improving plant effluents are outlined. Flow sheets illustrate the discharge of liquid wastes into plant sewerage systems, and the location and character of treatment facilities for removing objectionable constituents from waste waters. Disposal of recovered materials is discussed. Expenditures are outlined that have been made for waste treatment facilities during the relatively short period in which the American synthetic rubber industry has existed.

THE production of synthetic rubbers of all types in the United States until 1940 represented only a moderate effort by several of the larger chemical, petroleum, and rubber companies to develop possibilities along their particular lines of research and development. *Thiokol* was introduced commercially in 1929, but its production attained only modest figures. Neoprene entered the picture in 1932 and became a valuable rubber specialty, although production before the war reached only a few thousand tons annually. Not until early 1940 was an all-purpose rubber, such as GR-S, considered on a commercial scale, although extensive development had been conducted in the field of diene copolymers following initial German production of Buna S in 1935.

On June 25, 1940, the Reconstruction Finance Corporation Act was amended to authorize the R.F.C. to create corporations for the purpose of acquiring strategic and critical materials as defined by the President. On June 28 of the same year the President designated rubber as a strategic and critical material, and Rubber Reserve Company was created by the Reconstruction Finance Corporation. The original purpose of Rubber Reserve Company was to buy and accumulate a stock pile of natural rubber as a safeguard against possible war in the Far East. The later activities of Rubber Reserve, as explained in their reports (*5*), have been predominately concerned with the Government's synthetic rubber program. These activities have been unique in comparison with activities of other government agencies, in that Rubber Reserve has had the direct responsibility, from the date of its inception, for the formulation, correlation, and operation of a program involving a new industry of great magnitude.

March 28, 1941, Rubber Reserve requested four large rubber companies to submit proposals for the construction of four synthetic rubber plants, each with a capacity of 2500 long tons annually. In May 1941 the plans were revised to 10,000 long tons per plant. Immediately following the attack on Pearl Harbor the program was increased to 400,000 long tons per year, and after the fall of Singapore (February 15, 1942) the program was increased in successive stages to a total of 805,000 long tons installed capacity, including 705,000 long tons of GR-S, 60,000 long tons of Butyl, and 40,000 long tons of neoprene. Because of operating improvements this program later demonstrated that more than 1,000,000 long tons per year of the three types of rubber could be produced. In all, fifty-three plants involving forty-nine industrial organizations were constructed for the United States Government rubber program. These include not only the copolymer units, styrene plants, and butadiene plants utilizing both alcohol and petroleum for feedstocks and butylene feedstock units, but also necessary catalyst, chemical, and solvent operations.

RUBBER TYPES AND PROCESSES

The general types of rubber produced in the chemical rubber program are repeated here:

GR-S	Includes all-purpose GR-S types, such as GR-S-AC, GR-S-10, GR-S Black 1, etc. (*4*)	Copolymer of butadiene and styrene stabilized with antioxidants
GR-I	Butyl for pneumatic and general inner tube applications, coatings, etc.	Copolymer of isobutylene and isoprene
GR-M	Neoprene for special applications, such as oil and solvent, resistance, foam sponge, etc.	Polymer of chloroprene

GR-S is first produced as a latex by emulsion copolymerization of styrene and butadiene with tallow or other stearate oil-base soaps, and coagulated to crumb by one of a number of coagulating chemicals. GR-S-10 varies from GR-S in that a rosin acid soap is used as the emulsifying agent during copolymerization. Other chemicals are added during the copolymerization step to provide modification of the molecular structure of the copolymers and to control the extent of the conversion. Practically all GR-S plants operate on similar flow sheets. GR-S Black 1 includes an additional step whereby carbon black slurries are coagulated simultaneously with a given latex stream to produce a rubber containing approximately a third carbon black in the finished

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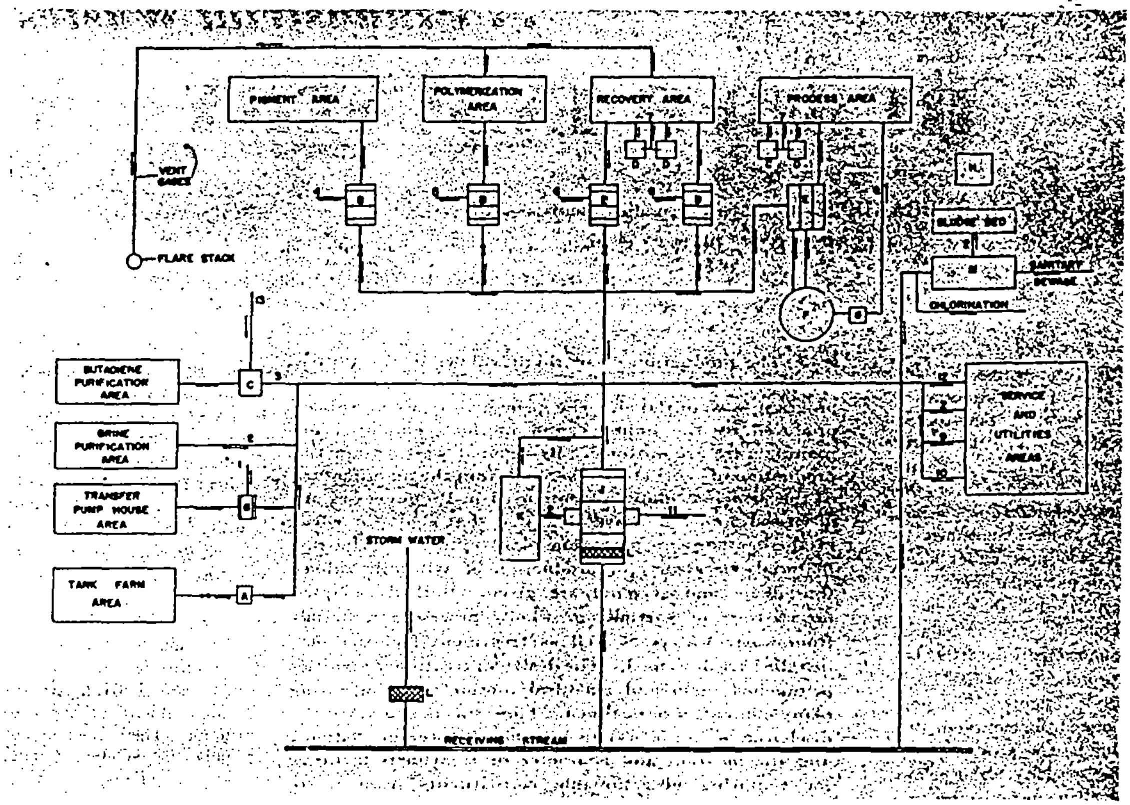

Figure 1. Flow Diagram of Waste Treatment and Disposal for a Synthetic Rubber (GR-S) Plant

A. Flame traps	*G.* Barometric sump	1. Styrene and oil recovered	7. Latex recovered
B. Regional separator	*H.* Burning pit	2. Sludge	8. Rubber crumbs scrapped or burned
C. Spent caustic pit	*J.* Final separator	3. Spent caustic	9. Boiler blowdown
D. Latex sump	*K.* Sludge bed	4. Soaps, modifier, and antioxidant destroyed	10. Cooling tower blowdown
E. Compartment tank	*L.* Hay filters	5. Polymer and styrene burned	11. Oils burned
F. Vacuator	*M.* Imhoff tank	6. Styrene and latex recovered	12. Oil
			13. Dilution water

product. GR-S is shipped in 75-pound paper-sacked bales in most instances.

NO indication produced LA

GR-I (Butyl) is produced by the copolymerization of small amounts of isoprene with isobutylene in the presence of a catalyst at temperatures below −150° F. and recovered from the solvent menstruum as a snow-white crumb. Extremely large quantities of hydrocarbons and solvents must be recycled in the process. The finished product is shipped in 50- and 75-pound cartons.

GR-M (neoprene) is produced by the emulsion polymerization of chloroprene, which is manufactured from acetylene and hydrogen chloride. Numerous ranges of viscosities of the finished polymer are available. Shipments are made in bags of 50-pound weight in the form of either rope or sheet.

Styrene, although produced by several different processes, presents in general a rather simple and straightforward plant flow sheet (*2*). Ethylbenzene, the basic intermediate, is produced from both alcohol and petroleum sources by alkylation of ethylene directly with benzene in the presence of a catalyst. Since commercial production of styrene was substantial prior to the war, the problems inherent in this operation were well understood.

Butadiene is produced from alcohol and petroleum. The operations of the alcohol-type plants as they were constructed were almost entirely similar; however, the petroleum-type butadiene process utilized three basic materials, including naphtha, butanes (*1*), and normal butylenes (*3*). The process for the recovery of products varied in that widely different types of solvent recovery systems were employed. Differences in solvents used created dissimilar process- and waste-handling problems.

Table I lists the plants of the government rubber program according to location rather than type and presents the water sheds involved in their operations. In certain locations the combined wastes of the operations present a cross section of all the typical operations necessary for production of a given type of chemical rubber. Thus, at Louisville, Ky., where the Ohio River receives the outfall from the plants, an alcohol butadiene unit, a carbide plant including facilities to produce acetylene and nitrogen, two GR-S copolymer units, and a neoprene plant are in operation. At Los Angeles, Calif., two copolymer plants, a petroleum butadiene plant, and a styrene unit utilize the Dominguez Channel as their outfall for industrial wastes.

BY-PRODUCT WASTES FROM SYNTHETIC RUBBER

A wide variety of organic chemicals are employed in the production of intermediate and final products of the synthetic rubber industry. The chemical characteristics of these compounds are well known when referred to the reactions that are essential in producing the quality of materials needed for production of superior grades of synthetic rubber. This knowledge, however, does not extend to the behavior of many of these compounds in water environment and their effect upon stream sanitation.

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Generally, hydrocarbons essential to these processes are only slightly soluble in water, so that measurements are best expressed in terms of parts per million. Many of these materials can be oxidized by bacterial activity in receiving waters and thus create an oxygen demand that may result in depletion of the dissolved oxygen content of the waters.

Earlier in the program ethyl alcohol was an important raw material used in the production of butadiene, but today the greater part of butadiene used in the industry is derived from petroleum products. Butyl rubber and neoprene are important components of synthetic rubber production but are produced in relatively small quantities compared to GR-S.

Table II lists raw materials used in producing GR-S and in preparing its two principal constituents, butadiene and styrene. Table III presents recent analytical data on typical GR-S plant liquid wastes. Recent average analytical data on typical butadiene (petroleum) plant liquid wastes are shown in Table IV and on styrene plant liquid wastes in Table V.

PROGRAM FOR SOLUTION OF WASTE PROBLEM

Since so many problems arose from the large scale operation of these new units of American industry (Table I), it was impossible to analyze each problem within a reasonable time and provide adequate facilities for the handling, recovery, treatment, and disposal of liquids, solids, and gases. Furthermore, in common with many war-built facilities, the plants of the rubber program were constructed with the least possible expenditure in time, labor, and money. Because of the lack of experience with most of the processes of synthetic rubber manufacture, many of the treatment and disposal problems were unique and required the attention of specialized personnel. In some cases it was necessary to undertake experimental programs of some magnitude. Many improvements had been carried out in 1943 and 1944 in localities where conditions of stream and atmospheric sanitation were critical. During 1945 and 1946 the remaining problems connected with waste disposal were surveyed in detail, improvement programs initiated, and many individual projects installed. Early in 1945 the following policy program was promulgated by Rubber Reserve:

> Liquid and gaseous discharges from all plants should be reasonably free from objectionable materials which might cause trouble when these materials are discharged into water courses or atmosphere.

Facilities for the adequate handling, recovery, treatment, and

Table I. Plants of the Government Rubber Program

Location of Plant	Plant Operator[a]	Type of Plant	Rated Capacity per Year	Water Course at Site	Final Receiving Body of Water
Naugatuck, Conn.	U. S. Rubber Co.	GR-S	30,000 L.T.[b]	Naugatuck River	Naugatuck River
		Modifier	1,800 S.T.[c]	Naugatuck River	Naugatuck River
Akron, Ohio	Firestone Tire & Rubber Co.	GR-S	30,000 L.T.	Municipal sewerage & Ohio Canal	Little Cuyahoga River & Cuyahoga River
	Goodyear Synthetic Rubber Corp.	GR-S	30,000 L.T.	Municipal sewerage & Haley's Ditch	Little Cuyahoga River & Cuyahoga River
	University of Akron	Laboratory	...	Municipal sewerage & Ohio Canal	Little Cuyahoga River & Cuyahoga River
Ashtabula, Ohio	National Carbide Corp.	Calcium carbide	72,000 S.T.	Field Brook	Ashtabula River
Toledo, Ohio	Sun Oil Co.	Butadiene	15,000 S.T.	Ditch and Otter Creek	Maumee Bay
Kobuta, Pa.	Koppers Co.[d]	Butadiene	80,000 S.T.	Ohio River	Ohio River
	[e]	Styrene	37,500 S.T.	Ohio River	Ohio River
Institute, W. Va.	U. S. Rubber Co.	GR-S	90,000 L.T.	Kanawha River	Ohio River
	Carbide & Carbon Chem. Corp.[d]	Butadiene	80,000 S.T.	Kanawha River	Ohio River
	[d]	Styrene	25,000 S.T.	Kanawha River	Ohio River
Louisville, Ky.	B. F. Goodrich Chem. Co.[f]	GR-S	60,000 L.T.	Municipal sewerage	Ohio River
	Natl. Synthetic Rubber Corp.	GR-S	30,000 L.T.	Ohio River	Ohio River
	Carbide & Carbon Chem. Corp.[d]	Butadiene	60,000 S.T.	Ohio River	Ohio River
	National Carbide Corp.[g]	Acetylene	1,500,000 cu. ft./day	Paddys Run	Ohio River
		Nitrogen	160,000 cu. ft./day	Paddys Run	Ohio River
	Du Pont Co.	GR-M	60,000 L. T.	Paddys Run & Ohio River	Ohio River
Memphis, Tenn.	Q. O. Chem. Co.[h]	Furfural	12,000 S.T.	Municipal sewerage & Wolf River	Mississippi River
Baton Rouge, La.	Copolymer Corp.	GR-S	30,000 L.T.	Monte Sano Bayou	Mississippi River
	Standard Oil Co. of N. J.[i]	Butyl	38,000 L.T.	Monte Sano Bayou	Mississippi River
		Butadiene	25,000 S.T.	Monte Sano Bayou	Mississippi River
Lake Charles, La.	Firestone Tire & Rubber Co.	GR-S	60,000 L.T.	Bayou D'Inde	Calcasieu River
	Cities Service Refining Co.	Butadiene	55,000 S.T.	Bayou D'Inde & Calcasieu River	Calcasieu River
Port Neches, Tex.	Firestone Tire & Rubber Co.	GR-S	60,000 L.T.	Outfall Canal & Neches River	Neches River
	B. F. Goodrich Chem. Co.	GR-S	60,000 L.T.	Outfall Canal & Neches River	Neches River
	Neches Butane Products Co.	Butadiene	100,000 S.T.	Outfall Canal	Neches River
Baytown, Tex.	General Tire & Rubber Co.	GR-S	30,000 L.T.	Scott Bay	San Jacinto River (Houston Ship Channel)
	Humble Oil & Refining Co.	Butyl	30,000 L.T.	Scott Bay	San Jacinto River (Houston Ship Channel)
		Butadiene	40,000 S.T.	Scott Bay	San Jacinto River (Houston Ship Channel)
Texas City, Tex.	Monsanto Chem. Co.[e]	Styrene	50,000 S.T.	Galveston Bay	Gulf of Mexico
Velasco, Tex.	Dow Chem. Co.[j]	Styrene	50,000 S.T.	Brazos River	Gulf of Mexico
Houston, Tex.	Goodyear Synthetic Rubber Corp.	GR-S	60,000 L.T.	Simms Bayou	Buffalo Bayou (Houston Ship Channel)
	Sinclair Rubber Inc.	Butadiene	50,000 S.T.	Simms Bayou	Buffalo Bayou (Houston Ship Channel)
Borger, Tex.	B. F. Goodrich Chem. Co.	GR-S	45,000 L.T.	Ditch & creek	Canadian River
	Phillips Petroleum Co.	Butadiene	60,000 S.T.	Ditch & creek	Canadian River
Los Angeles, Calif.	Goodyear Synthetic Rubber Corp.[k]	GR-S	60,000 L.T.	Dominguez Channel	Los Angeles Harbor (Pacific Ocean)
	U. S. Rubber Co.	GR-S	30,000 L.T.	Dominguez Channel	Los Angeles Harbor (Pacific Ocean)
	Shell Chemical Corp.	Butadiene	55,000 S.T.	Dominguez Channel	Los Angeles Harbor (Pacific Ocean)
	Dow Chem. Co.	Styrene	25,000 S.T.	Dominguez Channel	Los Angeles Harbor (Pacific Ocean)
	Southern Calif. Gas Co.	Butadiene	30,000 S.T.	Municipal sewerage & Los Angeles River	Pacific Ocean
El Segundo, Calif.	Standard Oil Co. of Calif.	Butadiene	18,000 S.T.	Pacific Ocean	Pacific Ocean

[a] Plants not included: Humble Oil & Refining Co., Ingleside, Tex., dismantled; Lion Oil Refining Co., El Dorado, Ark., private operations; Taylor Refining Co., Corpus Christi, Tex., dismantled; Premier Oil Refining Co., Cotton Valley, La., feed stock operations under contract; Great Southern Corp., Corpus Christi, Tex., feedstock operations under contract.
[b] Long tons. [c] Short tons. [d] In stand-by. [e] Private operation as of Oct. 15, 1946. [f] Private operation as of Jan. 1, 1947.
[g] Not wholly government-owned. [h] Private operation as of Nov. 1, 1946. [i] Includes one new plant and converted facilities.
[j] Presumably will be sold to Dow Chem. Co. [k] Original operations at 30,000 long tons, one unit idle.

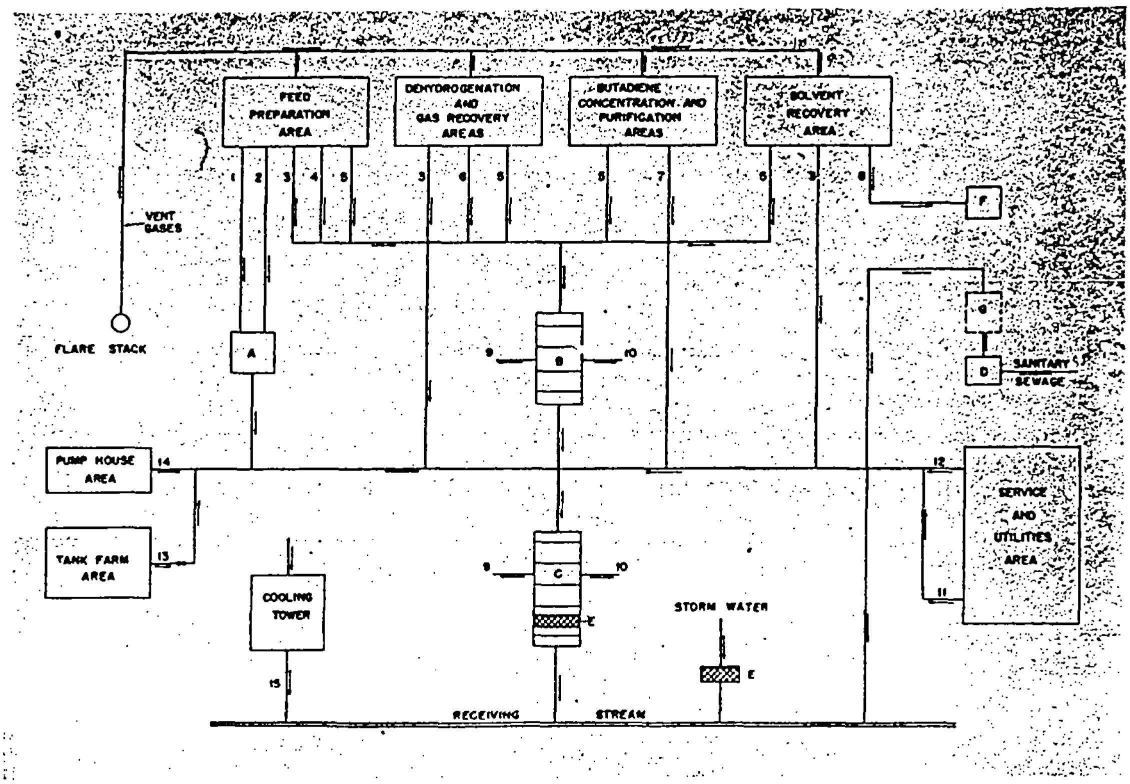

Figure 2. Flow Diagram of Waste Treatment and Disposal for a Butadiene (Petroleum) Plant

A. Neutralizing sump
B. Regional separator
C. Final separator
D. Imhoff tank
E. Hay filters
F. Burning pit
G. Sludge bed

1. Sulfuric acid leaks
2. Caustic soda washes
3. Still bottoms
4. Feed stock water wash
5. Washdown-gland cooling water
6. Second-stage compressor water
7. Water draw-off, minor amounts
8. Furfural polymer burned
9. Sediment to dump
10. Floating oils burned
11. Boiler blowdown
12. Clarification sludge, filter backwash, zeolite regeneration
13. Tank drainage, storm water
14. Pump leaks
15. Cooling tower blowdown

disposal of liquids, solids, and gases are considered as essential plant operating facilities.

Rubber Reserve does not wish to await developments of complaints regarding objectionable materials in the process wastes before taking action to remove these materials.

Steps should be taken to install, as soon as possible and in all plants, the necessary facilities to prevent the discharge of objectionable materials.

Should special conditions develop which would make further handling, recovery, and treatment of objectionable materials necessary, the operator of the plant should recommend the employment of competent and experienced specialists to study the problem and to recommend necessary practices and facilities.

Table II. Principal Raw Materials Required in Synthetic Rubber Production

GR-S, lb./long ton of product	
Butadiene	1610
Styrene	520
Soap	130
Miscellaneous chemicals (modifier, catalyst, shortstop, antioxidant)	40
Coagulant (salt or alum)	330
Butadiene[a], lb./1000 lb. of product	
Furfural (when used)	15
Copper ammonium acetate (when used)	6
Styrene, lb./1000 lb. of product	
Benzene	880
Ethylene	325
Catalyst	Small amounts

[a] With petroleum products as feedstock; other constituents vary according to types of feedstock used, which include n-butane, mixed butylenes, and petroleum naphthas.

Late in 1945 and early in 1946 it was necessary to take into account the plants which would not continue in the government production program. Hence, in some plants all construction projects were held in abeyance until the future operational programs were formulated. In the other plants the projects under way were continued, and the necessary new work was authorized.

The Office of Rubber Reserve employed consultants in 1943 and in 1945 to investigate facilities and methods for correction of industrial wastes. In 1943 and 1944 the United States Public Health Service contributed valuable studies on wastes from operating plants. In 1946, at the request of Rubber Reserve one of the authors (Powell) was directed to make an independent survey of all facilities in the plants operating in the program and to make recommendations on the adequacy of existing facilities and suggestions for additional practices and facilities.

During the period September 7, 1944, through March 21, 1945, five meetings were held by the Subcommittee on Plant Process Wastes of the Copolymer Operating Committee of Rubber Reserve Company. The members of this subcommittee represented all of the companies in the GR-S program in the United States and Canada. Blaw-Knox Company served as consulting engineers. Basic recommendations for the handling, treatment, and disposal of liquids, gases, and solids were formulated. Information was accumulated and exchanged for the benefit of the

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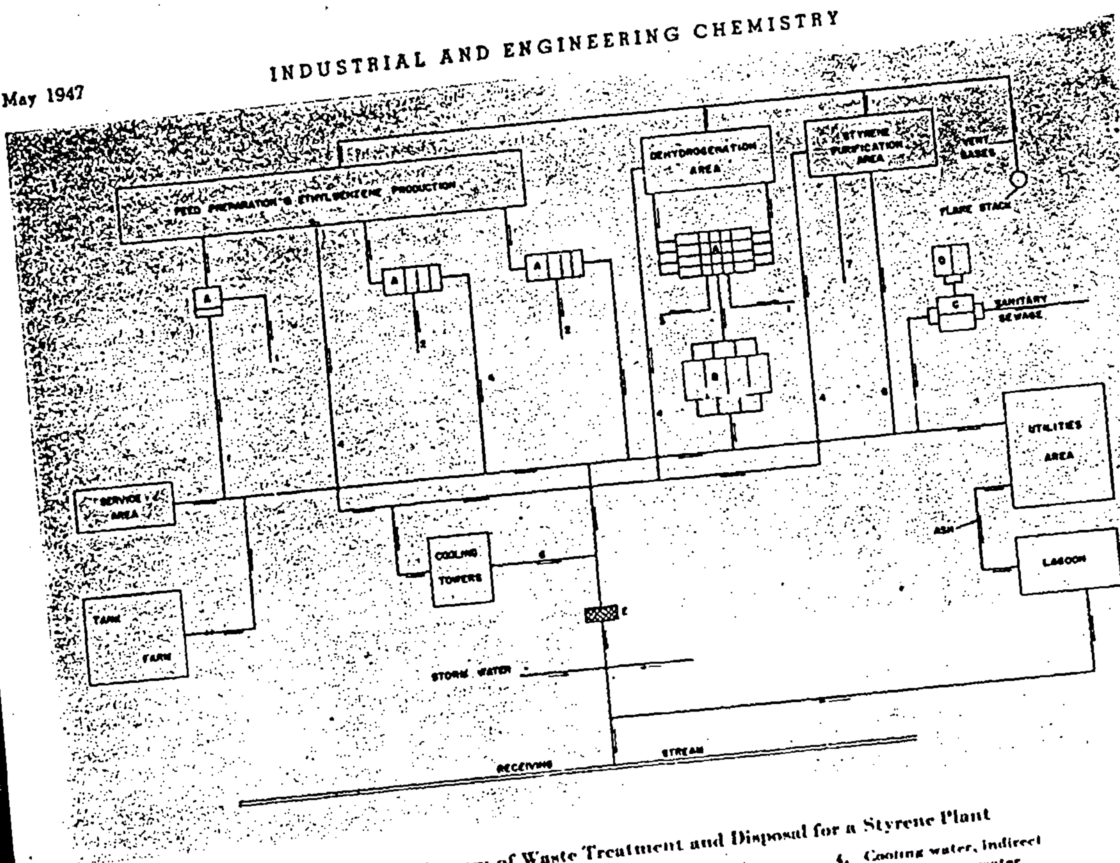

Figure 3. Flow Diagram of Waste Treatment and Disposal for a Styrene Plant

A. Regional separators
B. Primary separator
C. Imhoff tank
D. Sludge beds
E. Hay filter
1. Oil to fuel
2. Oil to process
3. Styrene recovered
4. Cooling water, indirect
5. Jet condenser water
6. Cooling tower blowdown
7. Tar to disposal pit

whole group. Similar meetings were held by the styrene producers (August 16 and 17, 1945) and by the butadiene producers (November 21, 1945).

From November 8, 1944, to date a group representing the Rubber Reserve agents and operators in Louisville, Ky., and for a somewhat longer period the Rubber Reserve agents and operators in Los Angeles County, have functioned as a committee for the purpose of keeping industrial waste problems under constant review. The plants of the Torrance, Los Angeles County, group have entered into a joint industrial waste treatment and disposal system which has given gratifying results.

WASTE TREATMENT FACILITIES

Treatment of industrial waste from plants producing synthetic rubber and raw materials essential to such production is founded upon three general principles that are commonly applied throughout the industry, although the methods devised vary considerably from plant to plant:

1. Potential waste solutions, separated from the product stream, are re-used directly or processed in auxiliary recovery equipment before entering into the waste sewer lines whenever such procedures are practicable.

2. Waste solutions from unit operations that cannot be recycled are treated in regional facilities before entering the main sewer, where mixing with other wastes from other sources takes place. Substances capable of polluting streams and of being removed from the water carrier in these devices are re-used or destroyed, depending upon the quality of the recovered materials. In some cases chemical treatment is necessary before satisfactory removal can be accomplished.

3. Process wastes from the several sources in each plant are usually combined after regional treatment and pass through a final gravity separator, where additional stream polluting substances are removed before discharge to the receiving stream. Chemical treatment is sometimes necessary for effective removal of undesirable materials and for proper adjustment of pH in effluents. Storm water, cooling water, and sanitary wastes are usually gathered in separate systems and are not passed through the final separator.

Figures 1, 2, and 3 are representative flow sheets for treatment of waste from major operations producing raw materials and final products in the synthetic rubber industry. Figures 4 and 5 illustrate waste treatment facilities used in the industry. General practice in plants producing raw materials or final products is to provide auxiliary equipment for treatment, recovery, and re-use of hydrocarbons that would otherwise be discharged to waste

Table III. GR-S Plant Liquid Wastes

Total solids, p.p.m.	5772
Volatile solids, p.p.m.	323
Fixed solids, p.p.m.	5449
Suspended solids, p.p.m.	136
Dissolved solids, p.p.m.	5636
Coagulable solids, p.p.m.	79
Oxygen consumed, p.p.m.	79
Biochemical oxygen demand (5-day, 20° C.), p.p.m.	50
Flow, gallons/minute	300[a]
pH	7.5
Population equivalent	1000[b]

[a] Production rate, 3000 long tons per month per line.
[b] Based on 0.167 pound of B.O.D. per capita per day.

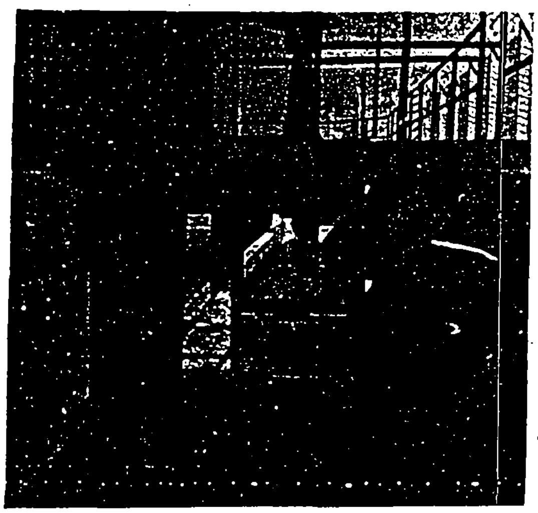

Figure 4. Facilities for Measuring Volume of Industrial Waste

waters. Separation of hydrocarbons from water by gravity results in water bottoms that may be partially or completely saturated with contacting materials. If removal of dissolved hydrocarbons is essential for protection of receiving streams, these wastes are subjected to partial distillation to effect improvement of the mixtures.

Equipment used for this purpose varies in each individual plant; in general the equipment consists of tanks in which decantation is employed to separate immiscible liquids, and stills or columns by which partial evaporation of the charge is effected. These result in removal of most of the materials dissolved in the water phase.

The majority of plants in this industry apply regional treatment to wastes at the point of origin. Many of the potential waste materials are only slightly soluble in water and can be removed from water impoundments by skimming. Other materials, such as latex and soaps, can be coagulated and removed by flotation or sedimentation in gravity separators. The design of such separators varies widely in different plants but consists essentially of concrete basins provided with under- and overflow baffles that trap floating or settleable solids. Retained materials of this nature are removed by manual or mechanical methods. If the quality of recovered materials is sufficiently high, the materials may be re-used in the process or sent to plant scrap. If contamination of recovered materials renders them unusable, they are destroyed by burning.

Detention times in regional gravity separators average about 2.5 hours with individual installations varying from 0.7 to 7.0 hours. These periods generally provide ample time for treatment and removal of recoverable materials.

Copolymer plants, where recovery of rubber crumbs from process wastes is essential, have departed from conventional designs in gravity separators. Large rubber crumbs float readily and rise quickly to the surface of water impoundments, but small crumbs rise sluggishly and may not reach the surface of the liquid in time to prevent discharge of solids into the receiving body of water. Some copolymer plants have installed vacuators for handling this type of waste. The liquid is aerated in external tanks and then enters large cylindrical vessels operating at a pressure of about 20 inches of mercury. The reduced pressure causes the entrained bubbles of air to rise to the surface and attach themselves to small particles of rubber; thus the bubbles assist in the flotation process. Suitable provisions are made within the vacuator for skimming floating material into barometric legs through which the recovered solids are removed from the unit. Recovered rubber goes to plant scrap or is destroyed, depending upon its quality. The clarified water is discharged to the sewer leading to the final separator.

Gravity separators of the types described are ineffective in removing dissolved materials; in some instances waste waters having a relatively high hydrocarbon content are collected after regional treatment and subjected to partial distillation as described, to reduce the dissolved content of materials that will affect stream quality adversely. Another expedient is aeration of waste solutions, which effects substantial reduction of odors and biochemical oxygen demand. Partial distillation and aeration are more effective in removing odors than in reducing B.O.D.

Process wastes, after regional treatment, are generally combined in a single conduit leading to a final separator. These separators provide means for final removal of separable materials that have not been removed by regional facilities. These units usually are modified American Petroleum Institute gravity separators, and are frequently provided with facilities for aeration and hay filters for removal of oils that have not been retained in the separator proper. Hay filters are effective for preventing oils or other suspended solids from entering the receiving body of water.

Final treatment facilities are provided, when necessary, with means for adjusting pH values and breaking oil emulsions. Relatively unstable oil emulsions may be overcome by lengthy storage or by treatment with acids. A method sometimes employed for this purpose is to pass the emulsified solution through a sand coalescer; this permits intimate contact between the emulsion and individual particles of sand. Separation is effected and the freed oil is removed in a subsequent gravity separator. Investigation of improved methods of dealing with emulsions is in progress.

Table IV. Butadiene Plant Effluent, Based on 50,000 Short Tons per Year, Furfural Recovery System

Sampling Point	Av. Flow, Gal./Min.	Dissolved Oxygen, P.P.M.	Biochemical Oxygen Demand[a] p.p.m.	Biochemical Oxygen Demand[a] lb./day	Population Equivalent[b]
Imhoff tank	13	0	93	14.5	87
Storm sewers	85	...	..	....	..
Lagoon, water clarification sludge	104	4.8	3	3.5	21
Final separator	1465	1.6	44	775.0	4650
Combined storm and process sewer	600	...	71	510.0	3060
Total effluents	2267	...	..	1303.0	7818

[a] 5-day, 20° C.
[b] Based on 0.167 pound of B.O.D. per capita per day.

Table V. Styrene Plant Effluent, Based on a Rate of 20,000 Short Tons per Year

Sampling Point	Flow, Gal./Day	pH	pO[a]	Odor[b] Concn.	B.O.D.[c], P.P.M.	Population Equivalent[d]
1. Benzene sump	1,410	8.35	7+	192	335	24
2. Ethylbenzene sump	1,330	6.52	6+	96	80	5
3. Styrene jets	776,500	5.82	6+	96	61	2370
4. Propane cracking sump	99,400	5.31	9+	768	340	..
5. Styrene cracking sump	88,000	..	...	...	...	..
6. Aerator feed (4+5)	187,400	6.75	8+	484	302	3390
7. Aerator discharge	187,400	7.02	5+	48	23.2	217
8. Sum (1+2+3+7)	966,640	..	...	...	...	2616
9. Main outfall[e]	26,400,000	6.69	4+	24	13.5	9900[f]
10. River water entering plant	26,400,000	6.00	3+	12	6.0	..

[a] With odor-free distilled water.
[b] Approximate equivalent of pO value.
[c] 5-day biochemical oxygen demand at 20° C.
[d] Based on 0.167 pound B.O.D. per capita per day.
[e] Includes cooling water where once-through system is used.
[f] After adjustment for B.O.D. of river water.

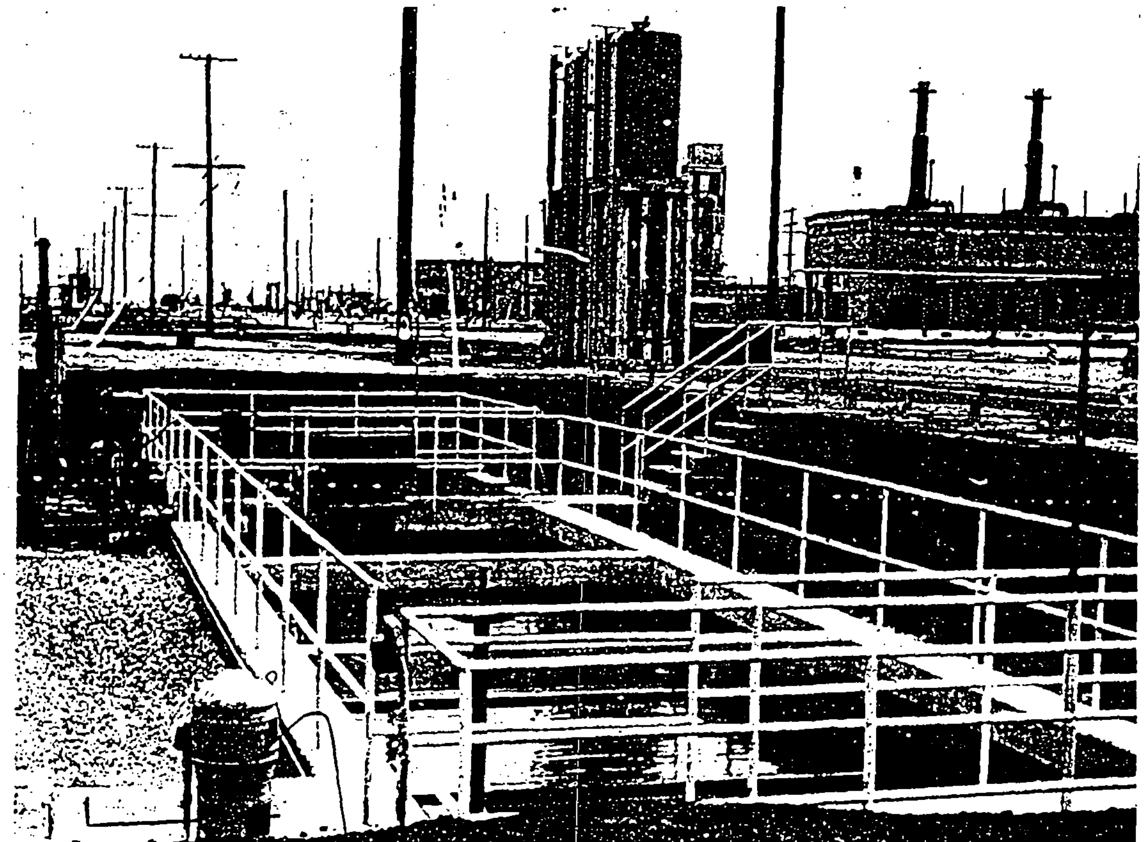

Figure 5. Final Gravity Separator for Industrial Waste

Considerable variation exists in the design of separators employed by the industry for final cleanup of waste waters before discharge to the receiving body of water. Detention time in such basins varies from 1.67 to 5.5 hours with an average of 3.75 hours. The velocity of flow through these units varies from 0.6 to 1.2 feet per minute. The detention period usually provides ample time for separation of materials lighter or heavier than water. Frequent skimming is resorted to in these units to prevent solution of separated hydrocarbons in unsaturated water. Generally, separate sewer systems are provided for storm water, which is discharged directly into the receiving stream.

Sanitary wastes are treated in septic, Imhoff, or other types of tanks and then, generally, on trickling filters. The final effluents from the treatment system are usually chlorinated. Sludge from the latter units is pumped to drying beds and later disposed of as fill or fertilizer. The design of such systems is comparable to similar facilities for treating sanitary wastes and requires no discussion here.

COSTS OF TREATMENT WORKS

More than $13,500,000 had been spent, as of March 1946, for the collection, recovery, treatment, and disposal of industrial wastes of the forty-one major rubber plants at eighteen different geographical locations. Of this amount more than $11,300,000 was spent for the handling of liquid wastes, including sanitary sewage, process liquids, and storm drainage. It is contemplated that new recovery, treatment, and disposal facilities will be installed as required in the plants continuing in operation. As of the end of 1946 it is estimated that additional improvements cost approximately $390,000.

Future operations of these plants will conform with policies laid down by the Federal Government until such time as they pass into the hands of private industry.

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